Emerging Software Development and Acquisition Approaches: Panacea or Villain

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Agenda

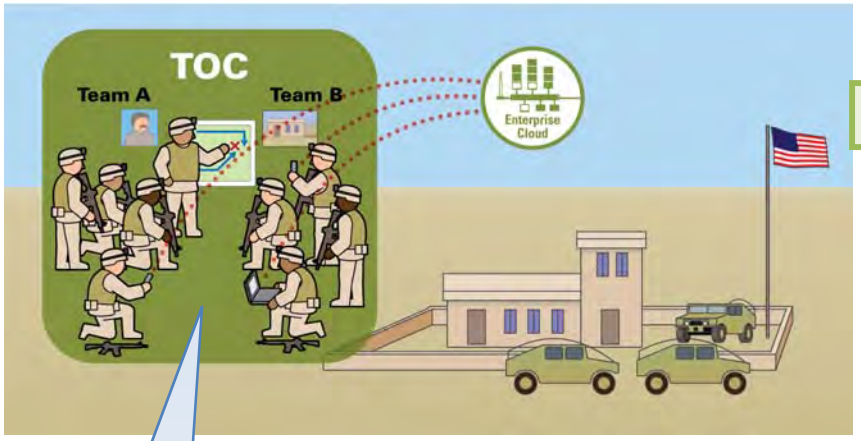
DoD needs and challenges

Potential approaches to address challenges (current progress and gaps)

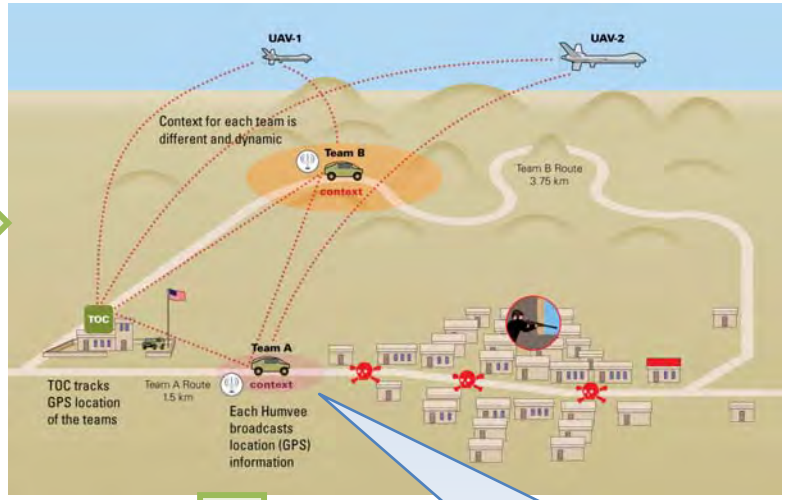
- Service orientation
- Cloud computing
- User-controlled adaptation in field

Conclusions

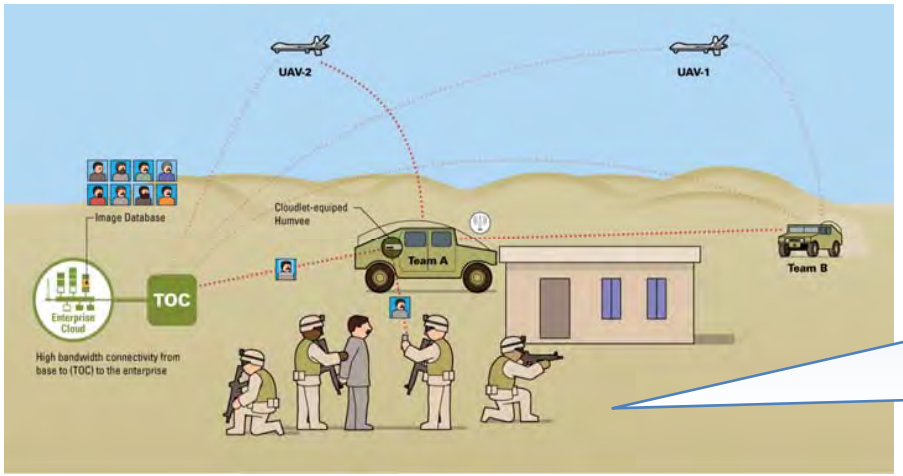
Mission Planning



Evolving Situation



Dismounted Warfighters



Software delivered to warfighters does not keep pace with changing missions

Warfighters cannot get the relevant information they need at the time they need it

The closer that warfighters get to combat, the fewer resources they have available

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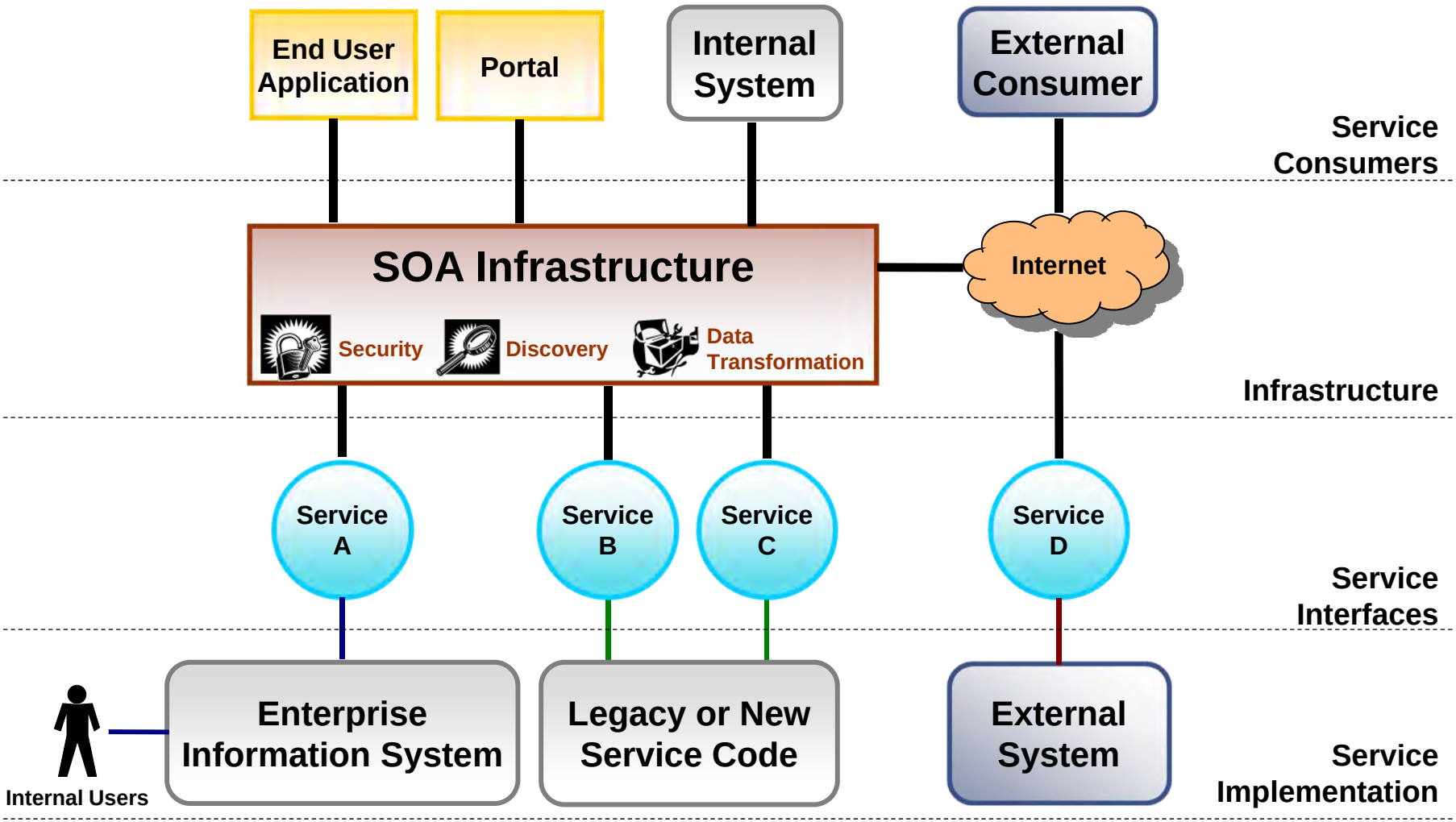
Service Orientation

Service orientation has become a common approach for implementation of distributed, loosely-coupled systems

- Services provide reusable business functionality via well-defined interfaces.
- Service consumers are built using functionality from available services.
- There is a clear separation between service interface and service implementation.
  - Service interface is just as important as service implementation.
- An SOA infrastructure enables discovery, composition, and invocation of services.
- Protocols are predominantly, but not exclusively, message-based document exchanges.

Components of a Service-Oriented System



Benefits Associated with Service Orientation

Cost-Efficiency

- Services provide functionality that can be reused many times by many consumers
- Services become a single point of maintenance and management for common functionality

Agility

- Via service discovery mechanisms, developers can find and take advantage of existing services to reduce development times

Legacy Leverage

- Separation of service interface from service implementation provides true platform independence

Adaptability

- Separation of service interface from service implementation allows for incremental deployment of services and incremental modernization

Common Misconceptions About SOA

1. SOA provides the complete architecture for a system
2. All legacy systems can be easily integrated into an SOA environment
3. SOA is all about standards and standards are all that is needed
4. The use of standards guarantees interoperability in an SOA environment
5. SOA is all about technology
6. It is very easy to develop applications based on services
7. Testing service-oriented systems is no different than testing any other type of system
8. Everything in a service-oriented system has to be a service

Service-Oriented Tradeoffs

Security

- Breaking systems into accessible services, service consumers, and infrastructure components increase the attack surface of a system
- Using an SOA-based system to enable inter-organizational functionality exposes organizations to threats that were previously hidden by firewalls

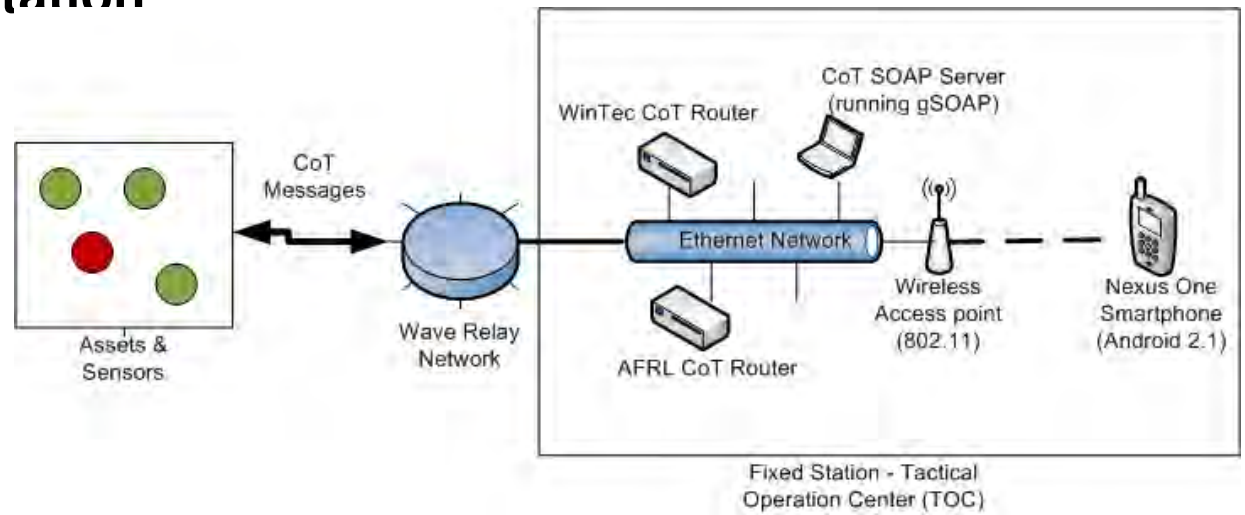
Performance

- SOA infrastructure adds agility, reusability, and adaptability but is costly in performance, particularly when using notations such as XML
- The need for increased security requirements degrades performance

Selected Challenges for DoD SOA Implementations

DoD Vision and Needs	SOA Technology	State of the Practice
Highly adaptable to changes in the environment	Design for Context Awareness	No agreement on how to represent context. No real implementation of contextual service discovery mechanisms.
Highly configurable to deal with multiple deployment choices	Design for Runtime Discovery and Composition	No standard for semantics. Tool support is very weak. No relevant examples of large-scale use.
Highly secure due to potentially classified content and malicious attacks	Securing SOA Infrastructures and Services	Federated identity management, security policies and policy enforcement, and trust establishment and trust brokering in SOA environments are all active areas of research.
Highly reliable and precise in a mission-critical context	Real-Time SOA	Current, widely-used SOA implementation technologies do not meet real-time requirements.

Extension of SOA to Address DoD Needs
CoT SOAP UDP App V1 (Camp Roberts – May 2010 TNT) – Fixed Station



- Assets (UAVs, cars) track a hostile vehicle and post CoT messages (video, location etc) to the CoT SOAP Server
- CoT SOAP Server consume raw CoT messages and provides CoT data as SOAP-over-UDP web service
- Android phone consume SOAP messages, processes and displays them

Experimental Engineering Decisions

Transport layer protocol defines interfaces available to applications that allow end-to-end communications; TCP is the most familiar and is best suited for situations with reliable transmission (solid network infrastructure)

- However, UDP was selected because TCP is not suited to situations where packet loss, mis-ordering, or garbling are more common
  - UDP tradeoff: it does not provide error correction

SOA uses two common messaging protocols SOAP and REST

- REST is simpler and increasingly more common
- We selected SOAP also hoping to take advantage of well-defined specifications, open source implementations, and support for security.
  - gSOAP on the CoT router-side and a modified kSOAP on the Android side

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Cloud Computing

"A large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet." *

jaworski.net

* I. Foster, Y. Zhau, R. Ioan, and S. Lu. "Cloud Computing and Grid Computing : 360-Degree Compared." Grid Computing Environments Workshop, 2008.

DoD Cloud Implementations [1]

DISA

- Rapid Access Computing Environment (RACE) — http://www.disa.mil/race/
  - IaaS private cloud
  - Allows authorized users (government personnel and contractors) to use a credit card to purchase a computing environment and be up and running within 24 hours
- Forge.mil — http://www.disa.mil/forge/
  - PaaS/SaaS private cloud
  - Collaborative development and use of open source and DoD community source software

NSA

- Private cloud (based on Google's Hadoop) to support a new collaborative intelligence data sharing application
- Distributed data centers host large amounts of disparate data that can be tagged, searched and analyzed by users

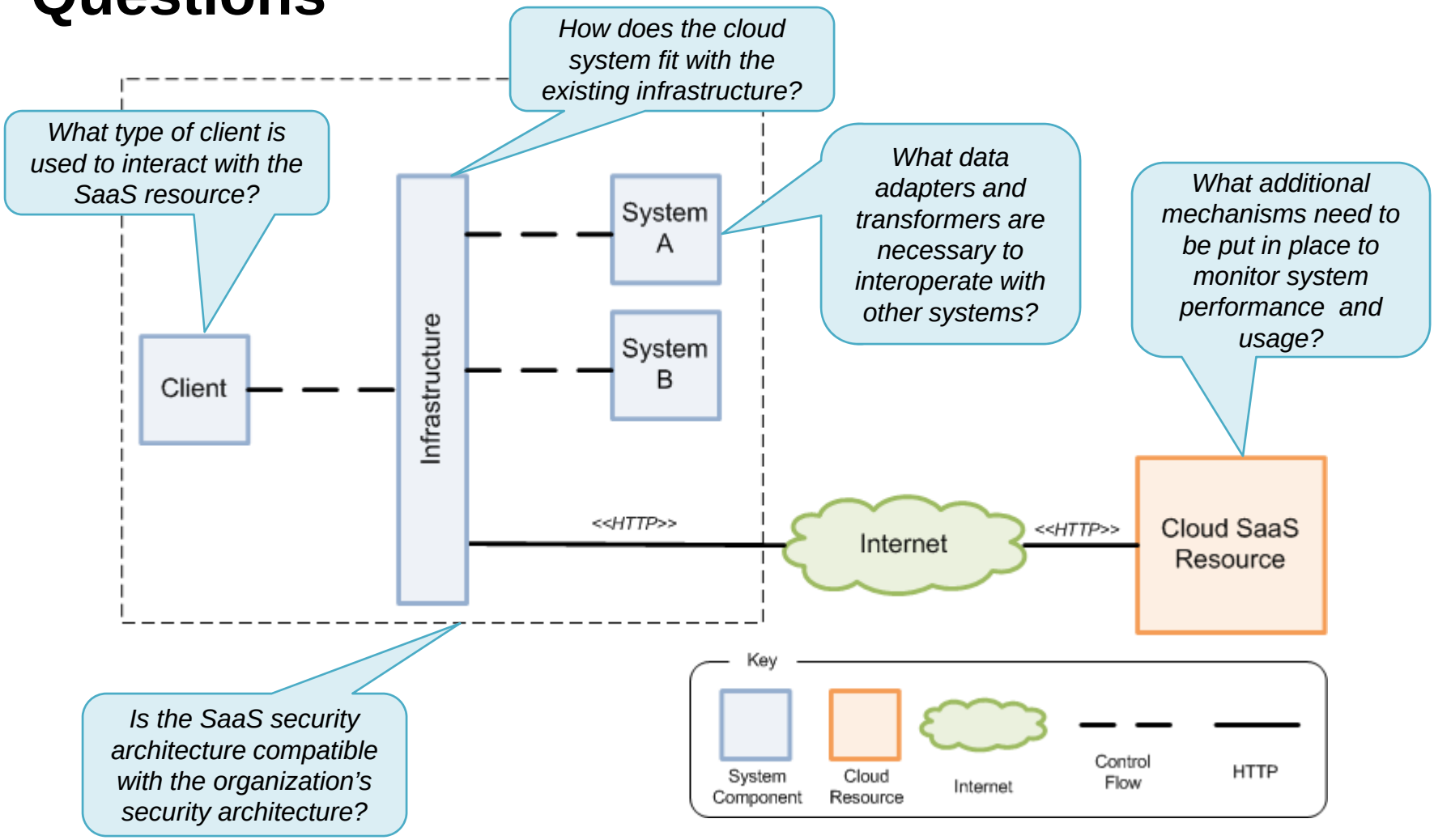
Drivers for Cloud Computing Adoption

Scalability	Organizations have access to a large amount of resources that scale based on user demand
Elasticity	Organization's can manually or dynamically decide on resource utilization based on changing needs
Virtualization	Each user has a single view of the available resources, independently of how they are arranged in terms of physical devices
Lower Infrastructure Costs	The pay-per-use model allows an organization to only pay for the resources they need with basically no investment in the physical resources available in the cloud. There are no infrastructure maintenance or upgrade costs
Availability	Organizations have the ability for the user to access data and applications from around the globe
Collaboration	Organizations are starting to see the cloud as a way to work simultaneously on common data and information
Risk Reduction	Organizations can use the cloud to test ideas and concepts before making major investments in technology

Barriers for Cloud Computing Adoption

Security	The key concern is data privacy: organizations do not have control of or know where their data is being stored
Interoperability	A universal set of standards and/or interfaces has not yet been defined, resulting in a significant risk of vendor lock-in
Resource Control	The amount of control that the organization has over the cloud environment varies greatly
Latency	All access to the cloud is done via the internet, introducing latency into every communication between the user and the environment
Reliability	Many existing cloud infrastructures leverage commodity hardware that is known to fail unexpectedly (NOTE: Disappearing as a barrier)
Platform or Language Constraints	Some cloud environments provide support for specific platforms and languages only
Regulation	There are concerns in the cloud computing community over jurisdiction, data protection, fair information practices, and international data transfer

SaaS: Examples of Architecture and Design Questions



Cloud Challenges 1

Cloud Computing is in essence an **economic model**

- It is a different way to acquire and manage IT resources

There are multiple cloud providers—**the cloud is real**

- Currently most cloud consumers are small enterprises
- Large enterprises are exploring private clouds
- The number of providers will most probably grow as people start seeing greater savings and improvements to reduce adoption barriers

Cloud Computing adoption requires **cost/benefit/risk analysis** to determine

- What resources to move to the cloud (if any)
- What situations warrant use of cloud resources, even for one-time situations
- Implementation of private clouds vs. usage of public clouds
- What risks are associated with using resources on the cloud
- What risks are associated to providing resources in the cloud

Cloud Challenges 2

Decisions from a cloud consumer perspective depend on

- Required control level
- Required security level
- Compatibility with local infrastructure

Decisions from a cloud provider perspective depend on

- Market/user characteristics
- Established SLAs
- Available technology

askbobrankin.com

In general, these are not fully technical decisions

- Processes — especially engineering practices
- Governance
- Cost/Benefit analysis

Research on Cloudlets for Resource Optimization for Mobile Platforms at the Edge

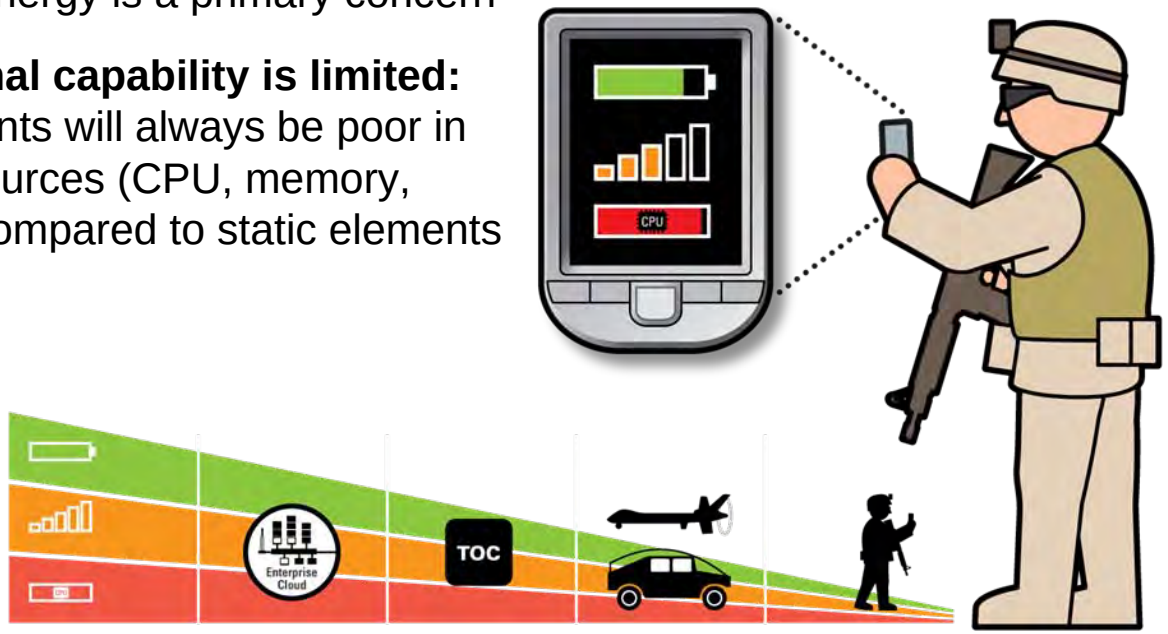
The closer you get to combat, the fewer computation, energy and network resources you have available

Group Battery Optimization

Battery life becomes critical:
Conserving energy is a primary concern

Group Computation Optimization

Computational capability is limited:
Mobile elements will always be poor in compute resources (CPU, memory, storage) as compared to static elements



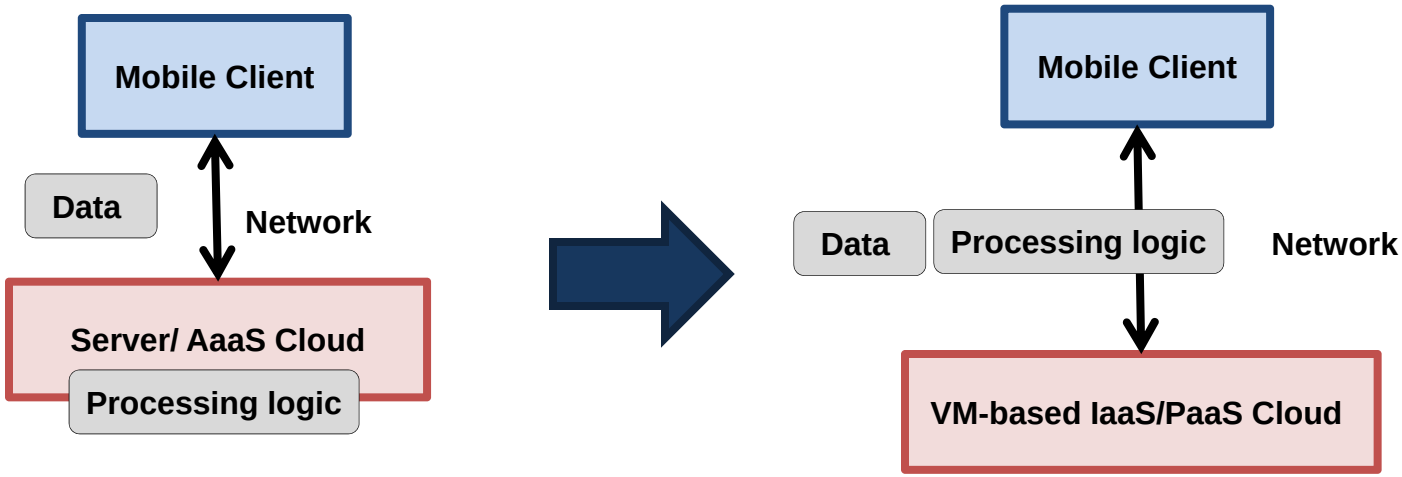
Goal

Develop software-based strategies for optimization of energy and CPU consumption that consider both the individual device and nearby peer devices

References: [Satyanarayanan 1996], [NAP 1997], [Silven 2007], [Ravi 2008], [Fuller 2011]

Cloudlet Concept

Offloading expensive computation to the cloud for remote execution

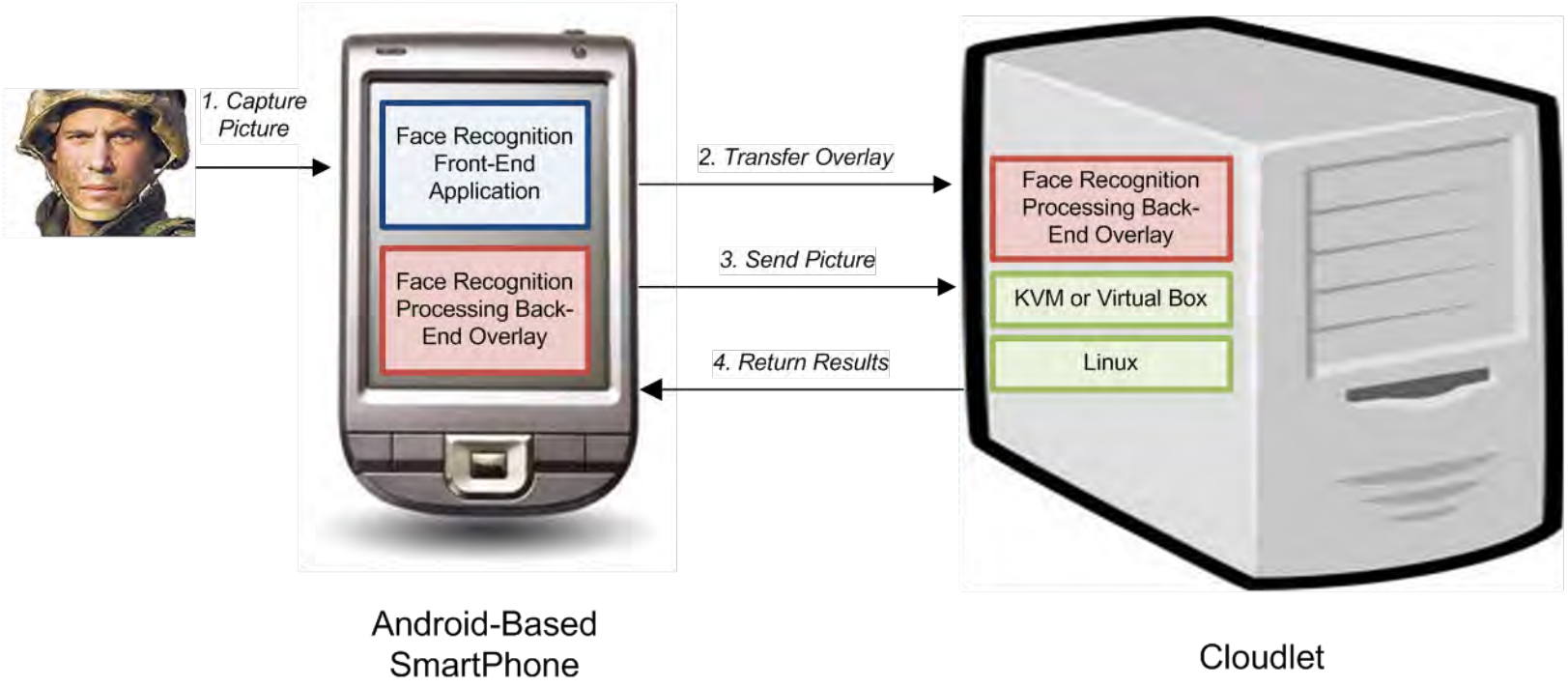


Similar to traditional client server.

Very common and mature architectural pattern used in today's mobile applications.

Still an area of research and is still not widely adopted by the mainstream

Cloud Computing in Tactical Environments



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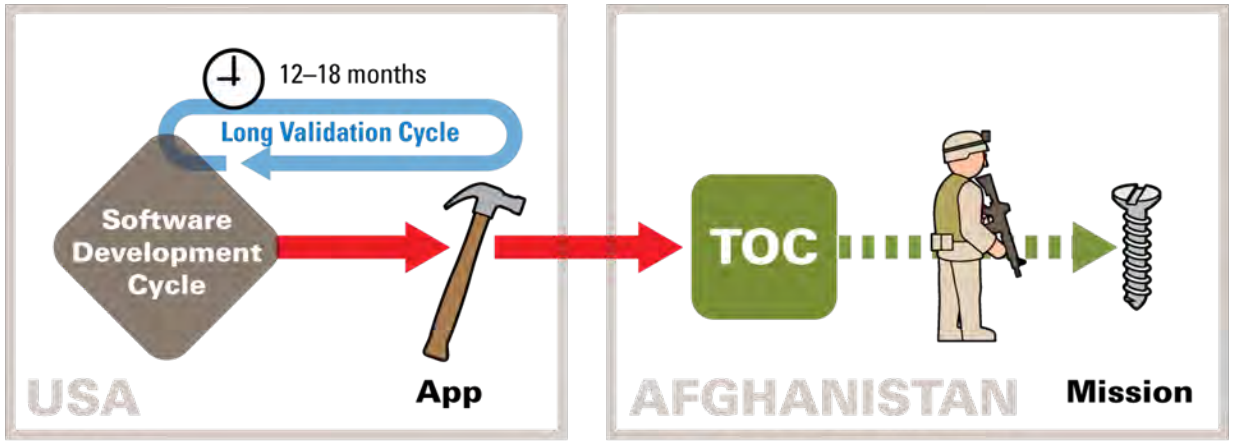
User-Controlled System Adaptation at the Edge[1]

Capabilities delivered to mobile devices at the edge do not keep pace with rapidly changing mission needs

- Mismatch between the mission needs and the capabilities provided by the tools
- Warfighters currently cobble together solutions in theater to meet emerging needs
- Warfighter-created solutions are of uncertain quality and can threaten the mission

Edge-Enabled Programming

Edge-Enabled Application Validation



t = months/years

Occurs at t + x years and lasts days/weeks

Goal

Develop end-user programming and architecture strategies for rapid adaption and validation of capabilities

User-Controlled System Adaptation at the Edge$_2$

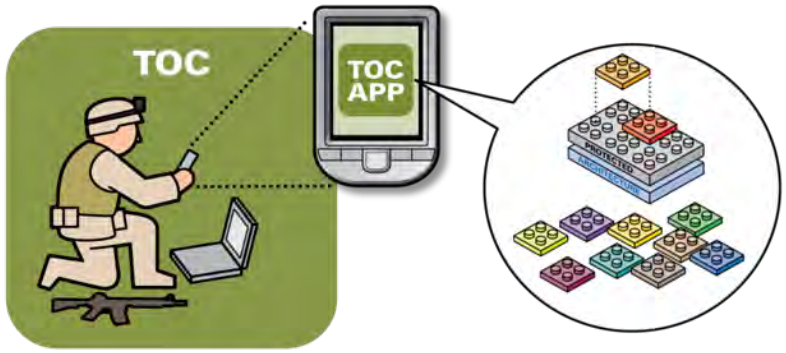
End-User Programming Capability for Handheld Devices that is Usable by Warfighters

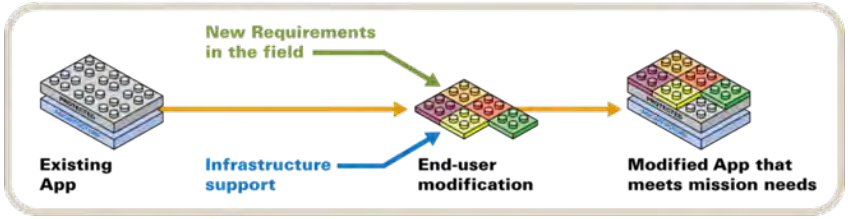
Develop end-user strategies to support adaptation of apps on handheld devices

- Employ *natural programming* to gather requirements for end-user adaptation [Myers 2008]

Create a domain-specific end-user programming environment that supports adaptation of mobile apps

- Enable dynamic creation of customized forms
- Incorporate additional sensors, data formats, more complex rules and layouts



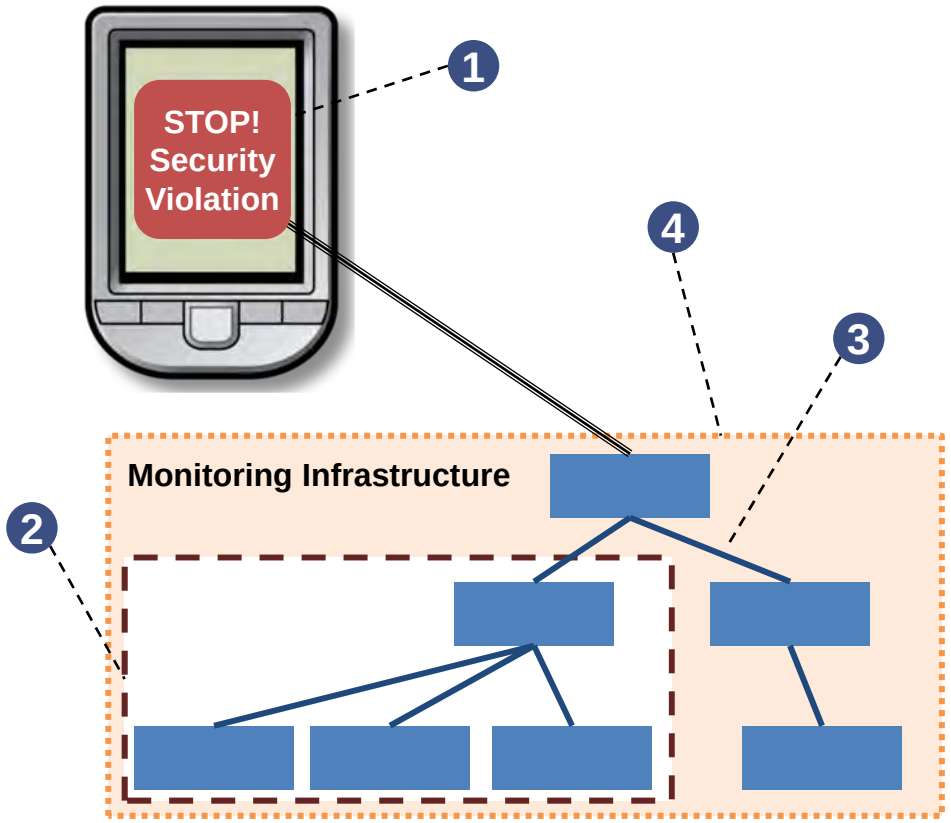


User-Controlled System Adaptation at the Edge$_3$

End-User Validation Strategies to Achieve Confidence in the Correct Operation of Handheld Apps Adapted by the Warfighter

Develop enhanced validation strategies for improved confidence

1. Provide feedback to warfighters on the effects of their modifications
2. Enforce firewalls on trusted parts of the system so that only new (untrusted) parts must be revalidated
3. Apply static analysis to verify selected properties of modified applications
4. Implement real-time monitoring to ensure that the application operates within its constraints



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DoD battlefield needs require

- Flexible adaptation
- Integration between diverse platforms and sources
- Discovery of available data and sensors
- Exploitation of mobile platforms
- Conservation of scarce resources of power and computation

Technologies and approaches offer potential to address these needs

- Mobile platforms
- Service orientation
- Rapid adaptation
- Cloudlets

These technologies are maturing in enterprise solutions (though they still have challenges

- Initial experimental results offer a step forward for the future

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